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THE AMERICAN

METEOROLOGICAL JOURNAL.

VOL. VII. ANN ARBOR, APRIL, 1891. NO. 12.

ORIGINAL ARTICLES.

A FRENCH TORNADO.

BY A. LAWRENCE ROTCH.

It is commonly supposed that tornadoes are peculiar to the United States, but this is not the case, a number having occurred in Europe, though less violent than those which are experienced in our Western states.

Such, for example was the tornado which devastated Dreux, fifty miles to the west of Paris, August 18, 1890, and which was investigated by M. L. Teisserenc de Bort, the chief of the general meteorological service of the French Meteorological Office, and by the writer. M. Teisserenc de Bort has presented a communication on this subject to the French Academy, and has also contributed an article to *La Nature*, from both of which the writer will quote in part.

The 18th of August had been warm and sultry. In the evening the writer, traveling by train through Normandy, remarked that the southern sky was illumined by almost continuous vivid lightning, though no thunder was audible, and the same phenomenon was observed at Paris. About 10 p m. a great cumulo-nimbus cloud appeared to the S. S. W. of Dreux, with incessant lightning accompanied by low thunder, while some heavier claps were attended by hail. At 10:10 a rumbling was heard, and in less than a minute tiles and debris were flying through the air, trees were uprooted or broken and several buildings demolished by a terrible gust of wind. A few minutes afterwards the sky was clear and the air calm.

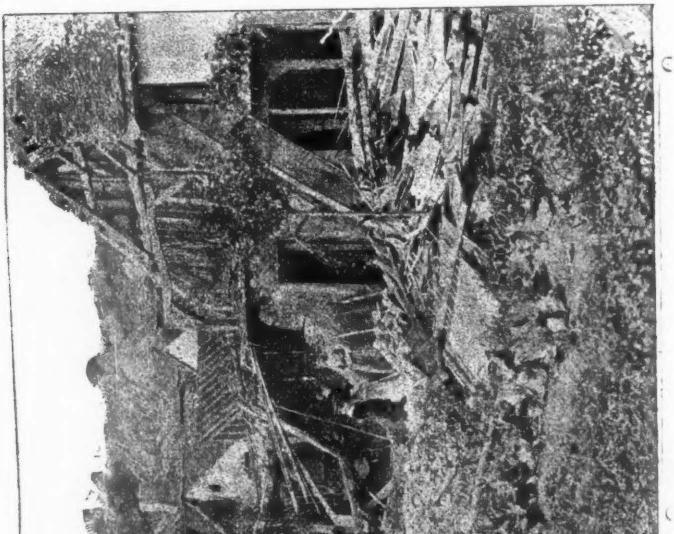

FIGURE 1.

The general track of the tornado, for such it undoubtedly was, extended southwest to northeast five and a half miles, and was about a quarter of a mile wide, and close to these limits no damage was done. Where the tornado first touched the ground the trees were directed towards the north, and at the end of the track lay mostly also in the direction of its passage, though some were upturned in the opposite direction. If the progressive motion of the tornado be considered, the contra-clockwise rotation of the whirl was fairly well indicated by the fallen trees. A steep hill about 150 feet high on the northwest, was not exempt from damage but seemed, nevertheless, to change the path of the tornado, which followed the valley until meeting another valley at right angles, the tornado was diverted from its original course and rose on to a plateau from which it soon disappeared.

The houses destroyed were mostly one-story wood-and-clay structures, but in some cases more substantial edifices were partially demolished, as seen in Fig. 1, which represents the ruins of the military bakery. Thus the chimneys of the court house were blown down and in falling carried away the roof, while the turrets of a brick dwelling-house were cut clean off. One person was killed by being overturned in a carriage, and the total damage to property was estimated at some $300,000.

At the instant of the tornado all the gas lights in Dreux, even those away from the tornado path were extinguished, probably by the sudden diminution of pressure, as shown by the register on the gasometer situated near the tornado track. This indicated a rarefaction of the air near the center of the whirl, which sustains the generally accepted theory. The damage by lightning was small, and there were no traces of burning by it except in the one instance cited below, so that the statement of M. Flammarion in *L'Astronomie* that this was not a tornado at all, but a whirlwind formed in an atmosphere charged with electricity, does not seem borne out by the observed facts. In one house however, there were unmistakable signs of electrical action. The brick exterior suffered little, only the roof and some windows being damaged, but certain window panes were perforated with round holes, whose interior edges were rounded by fusion, as shown in Fig. 2. The window curtains also were charred, proving conclusively that the lightning had entered. In this house all the partitions in each story which were at right angles to the track of the tornado, though built of brick and covered with plaster, were broken through, and the furniture dismem-

bered and scattered about the rooms. How these effects were produced it is impossible to say, though the question was of such interest to the insurance companies that experts, of whom M. Mascart was one, were asked to report on the matter. At Epone, nearer Paris, on the same night, a tornado destroyed a great number of forest trees, and throughout France destructive thunder showers occurred. They coincided with the passage over Western France of a secondary barometric depression, the principal minimum of 29.7 inches covering Scandinavia. The next evening another tornado, which worked even greater destruction of property and killed six persons, ravaged Saint Claude in the Jura mountains, and continued into Switzerland, over a course of some fifty miles.

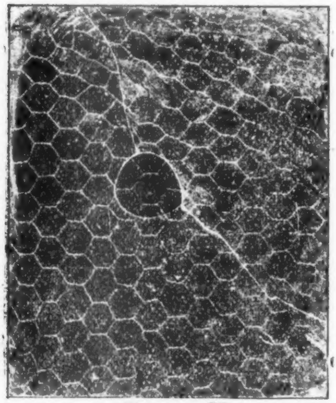

FIGURE II.

A "NORTHER" IN TEXAS.

BY RALPH S. TARR.

The "Norther," often so disastrous on the plains of Texas, comes upon the region without warning and with startling suddenness. The stories told on this score by the ranchmen seemed to me more or less fabulous until by chance I happened to observe the oncoming of the one which I am about to describe. There had been no doubt in my mind of the extremes of change, since a winter in camp had taught me the truth of the current reports in this respect; but the actual time of change had been at night in all cases, and I had no opportunity of observing its rapidity.

On the 14th of April, 1890, I was traveling across the Texas plains in a wagon, along the line of the Texas Pacific Railroad, in the vicinity of Vista, some distance east of Colorado City,

and at an elevation of something more than 2,000 feet above sea-level. The morning was calm and the sky partly overcast with cumulus clouds. Toward noon the sky overhead became nearly clear, but cumulus clouds hung over the horizon, particularly in the south and west. If there was any breeze it quite escaped my notice, but the day was warm and muggy. The plains at this place are perfectly open, entirely without trees, and extending northward into the Staked Plains.

In the afternoon a gentle breeze sprang up from the southwest, increasing in velocity very slightly, and at 3:30 p. m. blowing at the rate of perhaps ten or fifteen miles per hour. A thunder cloud was approaching from that direction, and dark, heavy clouds were also noticeable in the west and north. Rain was apparently falling at these points, while at the place where I was driving it was sprinkling. The temperature I am not absolutely certain about, but, judging from previous days, I am inclined to think that it could not have been far from 85° F. It was so warm that both myself and driver had our coats and vests off, and sleeves rolled up, and even then we were warm in spite of the fact that we were driving diagonally toward the breeze—that is, westward. The temperature was certainly not less than 85°, and may have been as much as 90°, though the humidity of the air tended to increase the effect of the heat.

At this hour (3:30) I noticed that the clouds in the north had begun to grow very black, then to separate and show dark yellow patches. My first impression was that a tornado was at hand, and my first impulse was to take the horses from the wagon for their safety, but I drove on as I was in a hurry to reach water for the night's camp. At 3:40 with the utmost suddenness the breeze from the southwest stopped blowing, and one began to blow from the north. It did not appear to veer through the west, but to actually jump from the one quarter to the other. At first it was a gentle breeze of no more than fifteen miles per hour, but its velocity rapidly increased, and in less than two minutes was blowing a gale, shaking the wagon top violently. I had no accurate means of determining the velocity, but compared with a gale observed under a similar circumstance near Fort Stanton the previous winter, which registered, at the signal service station, a velocity of sixty miles an hour, I should say that the velocity was not less than fifty miles per hour.

A similar striking change in temperature took place. In a minute there must have been a change of 15° at the very least

calculation. A thermometer which I carried in my pocket exposed to the wind, rapidly fell, and finally registered 65°. It became uncomfortably cold, and I was obliged to put on my vest, coat, overcoat and cover my knees with a blanket to keep warm, and so excessive was the change that even then I was cold.

Simultaneously with these changes the dark clouds from the north hurried on and went scurrying overhead, and a heavy cold rain fell, driven before the wind with great velocity. For some moments my horses refused to go, but turned tail to the wind, so great was its force. The excessive wind and rain ceased in about fifteen minutes, and the temperature rose 8°. A wind of about twenty-five miles per hour continued till after sunset, and all night a moderate breeze blew from the north; in the morning with a velocity of hardly more than ten miles per hour. With short intervals of quiet, rain fell all night until 4 a. m. on the morning of the 15th. During the 15th and the 16th it rained more or less continuously, and during the next week great quantities of rain fell, causing extensive washouts. Previous to this there had been practically no rain since the previous summer.

Although a mild norther, and occurring out of the regular season, it was sufficiently typical to illustrate the phenomenon and to show how unbearable one must be involving winter temperature at one extreme and summer at the other, the change coming in a few minutes.

THE NEW WEATHER SERVICE AND INTERNATIONAL METEOROLOGY.

By M. W. Harrington.

In 1872 Professors Bruhns, Wild, and Jelinek united in a call for a meeting of meteorologists at Leipsic to consult on the possibility of giving greater uniformity to meteorological procedure in different countries. The meeting was held in August and the Russian, Austrian, German, Italian, Dutch, British and other nations were represented among the fifty meteorologists present. Among the latter were Buchan, Buys-Ballot, Ebermayer, Neumayer, Ragona, and Scott, and many societies and heads of services, not represented in person, sent replies to the questions proposed for discussion.

As a result of this meeting an international congress was called, to meet at Vienna in 1873, and here there were twenty

different countries represented, including the United States by its Chief Signal Officer, General Myer. This Congress reached many official decisions and appointed a Permanent Committee to assist in carrying out its objects. The Permanent Committee had four meetings,—at Vienna in 1873, Utrecht in 1874 and 1878, and London in 1876. It called a maritime conference which met in London in 1874, and, finally, a second general congress of government officers, which assembled in Rome in 1879. Seventeen countries were represented in this congress, and General Myer was again the delegate of the United States.

The Rome Congress instituted an International Meteorological Committee, consisting of nine members from different European states, and charged with the duty of seeing that the decisions of the Congress were executed. The Committee met in Rome in 1879, in Berne in 1880, in Copenhagen in 1882, in Paris in 1885, and in Zurich in 1888. At the last meeting the Committee dissolved without calling another congress, but the furtherance of its purposes was left to Dr. Wild and Mr. R. H. Scott.

In 1876 an International Statistical Congress, which had assembled at Buda-Pesth, adopted resolutions relating to the unifying the work of the various countries in agricultural meteorology, and referred them to the Congress at Rome. As a result the International Committee of the latter was instructed to convene a special international conference on agricultural and forest meteorology. This was done, and the conference met in Vienna in 1880, and came to several important decisions. Its work was continued by a committee.

As a result of these various meetings, all attended by reprerentative meteorologists, and the most of them official, very many decisions were reached and recommendations made relative to the unification of meteorological work, and the economical use of meteorological appropriations, over the entire world. These decisions and recommendations, made under the most authoritative circumstances, and with so many guarantees of prudence and good judgment, have been generally adopted without objection.

There are some exceptions to this, and the most notable one is that of the United States. General Myer always declined to commit his service to the adoption of these methods. The reasons urged were undoubtedly weighty, but the reasons for bringing the United States weather service into better accord

with those of other great countries appear to the writer, and to others whom he has consulted, to be weightier still. The transfer of the service from the War Department to the Department of Agriculture removes some of the old objections and gives an opportunity to overcome others.

In order to see the character of the changes to be made, if the international plan be adopted, I will give a brief *resumé* of the requirements of this plan. These features are scattered through the publications of the international meteorological organizations mentioned above, from which I compile them. The publications were made in French, German, and English. I have used the English official edition, which was kindly furnished me by R. H. Scott, Esq., secretary of the Meteorological Committee of the Royal Society, and secretary of the International Committee.

1. STATIONS. The international plan includes five classes of stations,—the central office or institute, the central stations, and the stations of the first, second, and third order.

(*a*). *The Central Office*, or *Central Institute*, is the chief office, and is intrusted by the government with the management, collection and publication of the meteorological publications of the country. This would, of course, be Washington, as heretofore.

(*b*) A *Central Station* is a subordinate center for the management and collection of observations from a province or district. These have already been used by the Signal Service, and they have been given duties of local publication.

(*c*) A *Station of the First Order* is an observatory in which, without the collection of observations from other stations, meteorological observations are conducted on a large scale,—by hourly readings or with registering instruments, and with the greatest care and precision. Magnetic and electric observations may be intrusted to these stations. There are eight of these in Austria, a country smaller than Texas, and four have been planned for Brazil. There are but two in the United States, —the Blue Hill Observatory, near Boston, and the Central Park Observatory, New York. If we did as well as Austria, in the ratio of our area, we would have more than one hundred. There should at least be one for each great climatal division of the States, and there might very properly be one for each state.

(*d*) *Stations of the Second Order* are those where the usual tri-daily observations are made. The ordinary Signal Service

stations, and many of those of the state services, are of this order.

(*e*) *Stations of the Third Order* are those where only a part of the meteorological elements are observed. The rain-fall stations of the state services are of this kind. They are inexpensive, and should be as thickly scattered as possible. Their reports can be made by mail.

Such a classification of stations as the above would secure a double purpose. It would bring the new weather service into conformity with the services of other countries, and would permit the greatest practicable economy consistent with an efficient service. Economy is not needed in any narrow sense. The Weather Service will receive from Congress as large appropriations as are needed for work actually serviceable to the country. The only economy demanded is such a careful distribution of officers, instruments and work, that no station may be provided with men or instruments which it could not use, nor be required to do unnecessary work nor work which could be better done elsewhere. Such a classification would also make inspection easier.

Daily telegraphic reports would not be required from all these stations, but only from the relatively small number designated above as of the second order, and these should be judiciously distributed over the country. Their reports could be supplemented, when desired in critical cases, by telegraphic demands from other stations. In the case of local storms, the information could be collected and distributed from one of the central stations.

In European countries the agricultural and forestry meteorological stations are intrusted with special observations, in addition to the regular climatal ones. These are clearly defined, but may require some variation under special circumstances. Their reports relate to climate rather than weather, and could be sent in by mail. The observations must be made with unusual exactness, and often require special appliances; hence, special skill in observing. These services are generally independent of the general weather service; but, in the United States, where the general service passes into the hands of the Department of Agriculture, there is no need for the separation, and we should therefore have the additional order:

(*f*) *Agricultural and Forestry Stations.* These should form a part of each agricultural experiment station. Their work

could be made of the highest utility for agriculture. The skill required in them is of the same kind as that required in stations of the first order, and it may prove desirable to combine these stations with the latter. This would mean the establishment of a station of the first order with each of the forty agricultural experiment stations. This would give a fair number of these stations for the states, and would be an economy for the general service.

2. PUBLICATIONS.—It is in regard to publications that the Army Signal Office has departed farthest from the requirements of the international plan, and from the needs of climatologists. The international plan was devised with reference to placing in the hands of students of climatology the largest possible number of results of observation with the least possible delay, and in a form which could permit of their use with the least labor. Uniformity of publication possesses the great advantage of permitting comparison of results by the very simple process of opening the printed volume of reports and reading off the figures.

The official meteorological publications of the Signal Office have been numerous, and were often elaborate, expensive, and of high value; yet they have not fulfilled one of the above requirements. There is probably not a single question—except, recently, matter relating to Pike's Peak, (and that publication was made, not by the Government, but by Harvard Observatory)—which an American meteorologist could study, without having to write to the Signal Office for numerous manuscript additions to the printed reports. The Chief Signal Officer has always been very obliging in furnishing the information required; yet it is easier for an American to study the climate of Austria than that of the States.

The chief value of the meterological observations is to be found, not in the current daily predictions, but in their subsequent detailed and deliberate study by meteorologists; yet, in our service, their use has been practically limited to the first, the second being lost sight of, except as they could be used by the few officials at Washington. What meteorologist can foresee exactly what data, as to times and places, he will need, or is willing to give the Chief Signal Officer the trouble of having it prepared in manuscript for him? Moreover, the use of manuscript communications from the Chief Signal Officer involves him in a sort of personal responsibility for the publications depending on

them–a responsibility which he ought not to be expected to bear.

The requirements of the international plan of publication are simple and easily complied with. The publications should be in quarto with an arrangement of columns, etc., which has been found very convenient. The data may be on either the English or the centesimal scale, but the latter is recommended. The reports from the first order must be together, and printed *in extenso*, or, at least, in hourly means; the others in monthly means. The years to be employed are calendar years, and the means should also be given by lustra, beginning with the years ending with one and six in each decade. For a limited number of stations Dove's five-day means (seventy-three in a year, not six to each month, as some would do), should also be given, and there are other details of minor importance. I omit these, as my purpose is to give only such of the salient features as may show the character of the changes needed in case the international plan is adopted by the new weather service.

As to the recommendation of the decimal scales, the advantages are obvious and have often been argued. It is my opinion, however, that it is not wise to adopt them for observation. The English scales are so thoroughly incorporated into public use and thought, that the task of changing to the better should be left until the public is prepared for it by the educational process employed by the Metrological Society. The English scales should be continued, for the present, in the observations, in the predictions, and in other uses appealing to the general public; but for the formal publications of results—intended, as they are, for scientific use—the case is entirely different. The decimal scales are much better for scientific use, and the labor of changing from one scale into the other, to which American meteorologists are constantly subjected, is fairly intolerable, and should be remedied. This could be done, once for all, by clerks, when the results are prepared for printing. A few clerks at moderate expense would suffice to save, for a century to come, this annual tax on the hundreds of climatologists who use our American data.

3. Other Features.—The international plan defines many features of the instruments to be employed, while it leaves others to the directors of the individual services. For instance, some of the features of the thermometer and shelter are defined, while the make of the instrument is not. It also defines certain features of the reductions and has published a set of reduc-

tion tables. It insists on frequent inspections and the comparison of standard instruments. It defines certain expressions, giving them precise and technical meanings—as "rainy day," "hail," "sleet," etc.—and it gives a set of symbols which may be used to save space. These and similar matters can be compiled from the official reports already referred to.

It does not follow, from what has been said, that the relations of the Signal Service to the international plan have been discreditable, or even neutral, At the Vienna Congress, General Myer stated that the military organization of the Signal Service would prevent him from promising compliance with the requirements of the Congress, but he declared that the United States desired, not only to express its good-will, but to actively advance in every way the widest extension of systems of storm-warning and weather reports. He complied with the request of the Congress at Rome relative to the support of observations on Mt. Washington and Pike's Peak. The Signal Service has taken the leading part in the publication of international simultaneous observations, and the part it took in the carrying out of the plan of polar observations is known to all the world, and is very creditable to the present Chief Signal Officer, as well as to other Americans. The Signal Service received the formal thanks of the International Committee for its services in the matter of the Atlantic reports. Yet this committee, at its Paris Meeting, passed a minute which urged the Signal Service to put its publications into the international form. General Hazen was present at that meeting and promised compliance, and the Signal Service annuals have since shown decided improvement. Among meteorologists it has long been a reproach to the United States that, with the expenditure of so much money, it yet publishes so few observations and results in a form available for the students of meteorology and climatology.

The change of the weather service from the War Department to a civilian one, with practical scientific sympathies, gives opportunity to introduce changes found necessary. May we not hope that the able Assistant Secretary of Agriculture, in whose hands these matters appear to have been left, will see fit to adopt a plan recommended by the most competent authority and approved by the experience of many years. I have learned, since this paper was in type, another International Congress has been summoned. It meets in Munich, in August. General Greely, Professors Pickering, and Davis, and Mr. Rotch have been invited as delegates from this country.

CYCLONIC DEVELOPMENT AND PRECIPITATION ON THE PACIFIC COAST.

By Lieut. Jno. P. Finley, U. S. Army.

The weather of a place is generally the result of atmospheric conditions which have their initiatory development several hundred miles distant, and are brought, therefore, under the influence of cylonic circulation. In mountainous countries weather conditions are strongly localized. General cyclonic measurements are broken up under the extraordinary variations in temperature which characterize all regions where the surface circulation of the winds is continually interrupted and diverted. As the general movement of the atmosphere is from west to east, and all storms move in conformity with this influence, we must generally look to the westward in search of the conditions which give rise to our weather, wherever located, north of the thirtieth parallel.

Between the equator and 26° north and 26° south latitude storms move toward the *west* under the influence of that peculiar circulation of the atmosphere called the Trade Winds. These latitudes mark the apices of the parabolic paths of the cyclonic movements, where the direction of progressive movement, for a short distance, is north in the northern hemisphere and south in the southern hemisphere, and thence eastward in both hemispheres.

As to Pacific Coast weather, it all comes from the *west*, and its source of supply is the heat and moisture of the Japanese Current. All of the storms which enter this country from the Pacific Ocean proceed from the vicinity of the Aleutian Islands. This location, and farther to the southwestward, near to the Japanese Islands, is the breeding ground of the storms of the North Pacific. A proper understanding of this matter requires a knowledge of the conditions of storm development. It is important to know that a disturbance in the atmosphere of the nature of a storm necessitates, at the place of origin, a plentiful supply of heat and moisture. These two elements comprise the food of a storm, and without them cyclonic development is impossible. As any cyclone embraces an area of from 500 to 1,000 miles in diameter the source of food supply must be of proportionate extent and permanency. The breeding ground must have capacity to incubate and invest with moving power a continued succession of enormous atmospheric eddies.

Therefore in solving the weather problem of any region we must first locate its source of cyclonic development and supply. In the northern hemisphere there are only two such places of origin, viz.; the Japanese Current of the North Pacific and the Gulf Stream of the North Atlantic. The distribution of temperature and precipitation over any region is intimately dependent upon the peculiarities of cyclonic movement of that region. This is especially true of precipitation, and therefore the frequency and latitude of the easterly movement of cyclonic areas from the Pacific Ocean, over North America, is the key-note to the conditions which control the occurrence of rainfall in the Pacific Coast states. Some of these storms have been traced directly from the Japan Islands, and all from the Japan Current. The typhoon of the China and Japan seas may become the violent cyclone which sweeps the coast of Oregon and Washington with great fury. The course of these storms is northeastward from the Asiatic coast to Behring Sea, thence curving southeastward to the coast of British Columbia and Washington. In some instances they cross over to the southern portion of Alaska, or at points between Alaska and British Columbia. The period of greatest frequency and intensity of the North Pacific cyclones, coincides with the occurrence of the "wet season" in California. This season is more dependent, however, upon the latitude of the easterly movement of the cyclones. The "wet season" includes the months of November to March inclusive, and occasional heavy rains occur in October and April. There will be striking variations in the amount of rainfall during the season in different years, dependent solely upon the southerly movement of the cyclonic waves. Heavy rains can only occur in California when the cyclonic movement is southeastward through Oregon. When the storm center reaches southward into the northern portion of California and Nevada the heaviest precipitation will occur south of the forty-second parallel. To understand the distribution of precipitation attendant upon any cyclone we must know the peculiar characteristics which attach to each of the four quadrants of a cyclonic area, a subject which there is not space to discuss in this paper.

The remarkable rainfall in California during October, 1889, illustrates the effect of the southerly trend of cyclonic areas in augmenting the rainfall south of the forty-second parallel. During that month the precipitation exceeded the normal from two to thirteen inches, and was the heaviest for the month in a

period of forty years. An examination of the storm track charts for that month shows that all the cyclones, except two, passed eastward through *central* Washington and *northern* Oregon, and one extended *southward* into the *northern* portion of California and Nevada. In previous Octobers the storm centers had passed eastward along the *northern* boundary of Washington, and in most instances considerably *north* of that state. This was the case during the dry Novembers of 1862, 1876, 1884 and 1890, and explains other dry periods during the "wet season."

An explanation as to why cyclonic areas trend further southward in winter than in summer is found primarily in the declination of the sun north and south of the equator. Exceptional southerly movements in winter are due to peculiarities in the distribution of atmospheric pressure at the time which can only be reached by the cartographical study of immense atmospheric areas, embracing an entire continent. All cyclonic measurements in the Northern hemisphere take place at a higher latitude in summer than in winter. On the Pacific coast in summer the cyclones move eastward over British Columbia and to the northward, at which time California and the Middle Plateau are invested with the "dry season." But this season is only relatively dry, for rain does fall in every month of the year at various places within this region. It is really the season of violent local disturbances, such as hails-torms, thunder-storms, and "cloud-bursts." The precipitation of the "dry season" results entirely from local conditions and is not the effect of cyclonic circulation and movement, for we have shown that in summer the cyclones move eastward at a very high latitude. The rainfall of summer, then, must come from the evaporation of snow on the great mountain ranges of the Sierras. Observation proves this to be a fact. The great masses of snow collected on these ranges during the passage of the winter storms form the only source of moisture for the occasional showers and local storms of summer. No snow in winter means no rain in summer, and *vice versa.* Without these mountains to preserve the snows of winter for the water supply of summer, rains would entirely cease, the rivers dry up and the Middle Plateau, with California, would become a veritable desert, which the rains of winter would hardly resuscitate.

The cyclones of the North Pacific are first experienced at Alaskan stations in their eastward passage from the Asiatic

coast, then at stations on the coast of British Columbia, and finally on the coast of Washington and Oregon. These cyclonic movements illustrate the importance and practical bearing of the meteorology of Alaska on that of the northwest coast of the United States. The establishment of telegraphic stations of observation in Alaska is the key to the solution of the problem of obtaining timely warnings of the approach of storms from the Pacific. Stations of observations on the ocean are impracticable, if not impossible, but their establishment along the coasts of Alaska and British Columbia is already demonstrated. These stations must be connected by telegraph, for without the aid of electricity in overcoming the loss of time over great distances weather forecasts are impracticable for any part of the country. When the Aleutian Archipeligo and Alaska are connected by telegraph with the United States then the approach of the storms of the Japan Current can be heralded several days in advance to the seaport cities of the Pacific coast and the general weather forecasts for the interior made with greater accuracy. The construction of a trans-continental railway connecting the United States with Russia, would quickly provide the opportunity for the establishment of telegraphic stations of observation in Alaska. Stations on the Aleutian Islands could be connected by means of short land lines and cables to the main land line from Alaska southward. With these outposts on the very verge of the breeding grounds of the cyclones of the North Pacific the most important information could be secured concerning their development, frequency, severity and direction of progressive movement, and the data placed upon the daily charts of the Forecast Official at San Francisco. Reports from these extreme western stations, together with those on the coast of British Columbia, would be of great value in determining the approach and severity of the Pacific cyclones which enter the United States in Montana and Dakota.

We are to-day trying to project a similar plan which shall join, electrically, the meteorological stations in the West Indies with those of the United States in Florida. By this means the approach and severity of the West India cyclones can be telegraphed to all Atlantic seaports and those of the Gulf, a warning which is of immense value to commercial interests. There is thus briefly outlined two great schemes for the protection of the maritime interests of the Atlantic and Pacific coasts of this country, and the development of the means for practical study

of cyclonic movements from one ocean to the other. It affects the entire meteorological problem of this country on which the Government is expending nearly one million of dollars yearly.

North America has no equal in the field of opportunity for meteorological research, and the region which must receive the greatest benefit in such investigation is the United States.

CURRENT NOTES.

Brief History of the Canadian Meteorological Service. —In the twenty-first annual report of the Dominion Department of Marine, Mr. Carpmael gives a brief account of the service which we quote.

In October, 1870, the late Professor G. T. Kingston submitted to the Hon. P. Mitchell, then Minister of Marine and Fisheries, the outlines of a scheme for a Meteorological Service in Canada. He proposed that the organization should consist of:

I. A meteorological office to exercise supervision over the observing stations, as regards instruments, modes of registration, etc., and also to receive reports from them for reduction and compilation.

II. (*a*). A few well equipped stations where observations may be taken day and night, at equal intervals, not exceeding three hours, for determining certain constants needed in reducing observations from inferior stations.

(*b*.) A few similarly equipped stations, in telegraphic communication with the central office, to supply materials for storm warnings, *a* and *b* to be often, though not always, identical.

III. Numerous stations more or less furnished according to the duties to be performed.

At the time that he made this proposition he had (if we include the Ontario grammar schools, the use of the returns from which was allowed him by the Rev. Dr. Ryerson) opened correspondence with

29 stations in Ontario,
6 " " Quebec,
7 " " Nova Scotia,
2 " " New Brunswick,
Or in all 46 stations.

The scheme met with the approval of the Minister of Marine, and the sum of $5,000 was placed in the estimates for 1871–72,

for obtaining the necessary instruments, etc., with a view of ultimately establishing storm signals.

Professor Kingston then entered into correspondence with the Chief Signal Officer, Washington, D. C., to arrange as to the conditions under which he would be willing to furnish warnings when storms were expected, to Canadian ports, as with the small number of stations, and inadequate money appropriation at his disposal, it was impossible for him to undertake that work at the head office at Toronto. At the same time he entered into correspondence with additional stations in Canada and in Newfoundland, so that by the end of the year he had in communication with the head office 123 stations in Canada and two in Newfoundland.

During 1872, reports were received from 115 stations, of which 74 were reporting only rain and general weather, and of these rain reports, 19 were incomplete.

The expenditure in the fiscal years 1872-3 was $10,000, and during 1873 reports were received from 93 stations, and by the end of the year 33 stations had been equipped for the display of storm signals. The expenditure during the next three fiscal years was as follows:

1873-4	$33,491 03
1874-5	35,079 76
1875-6	37,000 00

The year 1876 marks an era in the history of the meteorological service. Up to this time no daily forecasts, popularly known as "probabilities" had been issued, and for all storm warnings the service had depended on the signal office at Washington.

Early in this year, however, arrangements were made with the Chief Signal Officer, by which a considerable number of telegraphic reports were handed, three times a day, to an agent of the Toronto office at Buffalo, N. Y., and telegraphed to Toronto. Later in the year, after an interview between the acting superintendent of the Canadian Service and the Chief Signal Officer, arrangements were completed by which additional reports of observations at United States stations were furnished daily, and forwarded direct from New York. Daily forecasts of the weather, based on these reports, together with those from stations in Canada, were issued by the Toronto office, and also storm warnings when considered necessary. The daily forecasts were sent

out at 10 a. m. each week-day, from the beginning of October, and were published in the afternoon papers.

At the close of 1876 there were reporting to the head office 101 stations in Canada and six in Newfoundland, of which 14 sent reports three times a day by telegraph.

From the 1st of October, in the following year, the daily forecasts were transmitted by telegraph to 75 of the principal places in Canada, west of Quebec, and posted up both in the telegraph offices and post-offices. On the 3d of December this service was extended to 20 places in the Maritime Provinces.

In 1879, the number of places receiving the "probabilities" was further increased to about 125, which included five stations in Prince Edward's Island. In the same year five new telegraph reporting stations were added to the list of those reporting to the Central Office, viz.: Yarmouth, N. S., Humboldt, Battleford, Edmonton, N. W. T., and Prince Arthur Landing, on Lake Superior. The total number of stations reporting by mail to the Central Office was, at the end of this year, 146.

Early in the year 1880, Prof. G. T. Kingston, who had been superintendent of the meteorological service from its first establishment, was obliged by failing health to resign his position. He was succeeded by Charles Carpmael, M. A., F. R. A. S. During this year five new storm signal stations were established, and arrangements were made with the railway companies to have the daily probabilities posted at their stations, and with the telegraph companies to have them posted at 300 places fairly distributed over the different parts of the Dominion reached by them. In the following year the number of stations receiving the probabilities was again greatly enlarged, and their usefulness very much increased by their being issued at 1 a. m., so that they might be posted as soon as the telegraph offices opened in the morning, instead of at 10 a. m., as had been previously done. The publication of the probabilities was further extended in 1882 to every office on the lines of the Great Northwestern Telegraph Company, which embraces practically the whole of Ontario and Quebec, and two parts of New Brunswick. In the remaining portions of New Brunswick and in Nova Scotia they continued to be posted as previously. Arrangements were made, too, in this year with the governments of Ontario and Manitoba, under which observations of rainfall at a large number of stations in these provinces were taken and forwarded to the meteorological office at Toronto.

The observatories of Quebec and St. Johns, N. B., were placed under the supervision of the meteorological service in 1883. A system of "train weather signals" was inaugurated in 1884, whereby forecasts as to the general weather were disseminated among farmers and others living in sight of the railways by means of discs carried by the morning trains to indicate either "fair," "showers" or "rain." At the end of this year there were 267 stations reporting to the central office, of which twenty-four reported three times a day by telegraph.

Notwithstanding the immense extension of the service since 1879, the expenditure had increased less than $10,000, that in 1878-79 having been $40,400, including the Quebec and St. Johns observatories, and 1883-84 it was $50,160.

Since 1884 the service has continued to grow, so that at the present time, December, 1888, we have 354 stations reporting to the central office, of which twenty-seven report by telegraph. Instruments have also been furnished to a number of Hudson Bay posts, and observations will be taken shortly, if they are not already being taken, which will add greatly to the extent of country from which statistics are obtained. The grant for the present fiscal year is $55,000.

THE WORK OF M. HERVÉ MANGON.—In the *Annales* of the French Central Meteorological Bureau for 1889, printed in 1891, M. Th. Moureaux gives an account of the work of M. Mangon, President of the Council from its organization until his death, and an abstract of his observations. He established on his property in Normandy a model meteorological station, at which observations were begun in 1868, and have been continued to the present time. He was especially successful in devising new registering instruments, and improvements in the old. His thermometer shelter was a movable one, easily set for any hour. In his apparatus for taking temperatures in inaccessible places, a table connected a metallic air-reservoir, placed at the point where temperatures were to be taken, with laboratory apparatus, and the observation consisted, as in Becquerel's electric method, in equalizing the temperatures. He invented an integrating rain-gauge, and also a registering gauge. But the most unique of his instruments were one for registering the time of rain, and one for observing its temperature. They were very simple; in the first, a band of paper, soaked with ferric sulphate, dried, then sprinkled with nutgall,

was gradually wound by clockwork and partially exposed to raindrops. The paper blackened where wetted. For the second, the rain fell in a funnel, emptying through a horizontal tube in which was placed a thermometer. He also invented an evaporimeter of simple character, erected a windvane riding on floats, and devised a register of direction and velocity of wind which is not dissimilar in principle to that of Lieut. Gibbons.

M. Mangon was especially interested in the application of meteorology to agriculture, as is shown by instruments applied to details of rainfall, and by his papers. The *résumé* of his twenty-one years of observations in the *Annales* makes a fitting memoıial for so sincere a friend of the science.

THE NEW WEATHER BUREAU.—Our readers may be interested in the officials provided by the law for the new bureau, and other financial details about it. There is to be a Chief of Bureau, at a salary of $4,500 per year; one professor of meteorology at $4,000, four at $3,000 each, and three at $2,500 each. There are also an assistant chief of bureau at $3,000, an executive officer at $2,500, a chief clerk at $2,250, three chiefs of divisions at $2,000 each, and a bibliographer and librarian at $1,600. In all, in the city of Washington, the appropriation amounts to $182,330 for salaries, $10,775 for fuel, lights and repairs, and $13,783 for contingent expenses. Outside of Washington the appropriation is, for salaries $323,900, for contingent expenses, $348,965.50. These make a grand total of $879,753.50.

The appropriation for the present weather service for the current year was $816,956, and the new appropriation is an increase of $62,797.50. This is accounted for by the addition of $50,000 for more perfectly extending the benefits of the service into agricultural regions, and by the fact that under the present arrangement five of the leading officials were assigned from the army. Their salaries aggregated $19,500, and these places must now be provided for in the weather bureau appropriation.

No appointment has yet been made to the position of Chief of the Weather Bureau, who must take his place on the first day of next July. It is quite possible that the present Chief Signal Officer will be detailed from the army for this duty, and Professor Abbe, Professor W. M. Davis, Professor Nipher and Dr. Hinrichs are some of the other names of prominent meteorologists mentioned as possible candidates.

NOTE ON THE HISTORY OF RAIN GAUGES.—Mr. G. J. Symons read a paper on this subject at the March meeting of the Royal Meteorological Society. It appears that Sir Christopher Wren, in 1663, designed not only the first rain gauge, but also the first recording gauge, although the instrument was not constructed till 1670. The earliest known records of rainfall were made at the following places: Paris, 1668; Townley, in Lancashire, 1677; Zurich, 1708, and Londonderry, 1711.

Mr. Symons gave a very full account of the various patterns of rain gauges, and in most instances pointed out the merits or defects of each.

A NEW LIGHTNING PROTECTOR.—In a late number of *Science** Mr. N. D. C. Hodges, describes a new method of protection from lightning. After first stating the problem to be the harmless conversion of the energy which does the damage and which is assumed to exist just previous to the lightning flash in the column of air between the earth and cloud, he explains why in his opinion the old rods constructed when only the two facts of the attracting power of points for an electric spark (or rather, as we shall see further on, for discharges of high potential) and the conductivity of metals were known, and based upon the idea that the lightning discharge was conveyed around the building and away into the ground, are defective. Arguing then from the assumption that the electrical energy will have a maximum value on the surface of the conductors that chance to be within the air-column, and that consequently "the greatest display of energy will be on the surface of these very lightning rods that were meant to protect," he questions whether a better means of protection would not be afforded by improving the form of the rod. A company has been formed and patents obtained we believe for this new form of lightning rod or lightning protector. As we understand it the rod will consist, at least theoretically, of appropriately sized wire-pieces—which are to be fused or volatilized by the passage of the lightning; the energy being thus harmlessly converted. Undoubtedly there is room for improvement in the form of protector, conductor or discharger (or by whatever name we may call it) to be used in dealing with discharges of such high potentials as exist in lightning flashes. The principle of converting the electrical energy into heat is not quite new, however, and in this JOURNAL for

* *Science*, March 6, 1891.

1885, page 64, in an article on Protection from Lightning is described a device of Mr. Edison's for protecting electric lighting apparatus from lightning. The device, though now perhaps somewhat old, and possibly supplanted by lead fuses, consists of two conductors extending from each side of the external circuit to the earth. One is of high resistance and one is of low resistance. We insert in these two earth circuits an arrangement for controlling the low resistance circuit by the current in the high resistance circuit. A fusible wire is inserted in the high resistance, and an electro-magnet controlling a circuit closer, acting upon cessation of the current. In case of the passage of a lightning flash along the out lines, and coming into the dynamo room, the closing of the low resistance circuit affords a ready ground. The total damage in such a case is the fusing of a few inches of fine wire.

The really important part of this new invention is, that in its theory, it emphasizes the fact that the seat of the electrical energy is, and must be—not in the cloud or in the earth, just preceding a flash of lightning, but in the air column between cloud and earth. This is exactly what our electrometer work has shown us, and it is now possible to tell from the value of the potential, indicating the electric pull upon the air, at right angles to the line joining the ground and the cloud—whether or not a flash of lightning will occur. Within a darkened room where the heavens could not be seen nor any reflection of the flash enter, we have timed the lightning flashes from the peculiar and characteristic "pulls" and "let-ups" or "breaks," on the needle of the electrometer, as accurately done to the fraction of a second, as one could do, outside, watch in hand. And the electrometer needle gives the fuller information; for unseen flashes are frequent.

Whether a lightning rod protects or not is a mooted question and it is only a few years ago (at the meeting of the British Association in 1888) that the matter was most thoroughly discussed. The function of a lightning rod would seem to be two-fold—first, to prevent a flash of lightning, and secondly, to carry off the discharge. Dr. Lodge it will be remembered, drew attention to what seems to appear more certain every day, that the lightning flash is a discharge of an oscillatory character; and certain relations exist between the electro-magnetic inertia or self-induction and the rapidity of oscillation. Laboratory experiments, however, are not always to be implicitly relied on and

at this very meeting the concensus of opinion among those who had practical care of telegraph lines was that cases were few (if any) where rods properly erected failed to protect.

The whole question of the theory of the lightning rod, however, is in course of revision, and in a few years, especially as we become more familiar with the laws prevailing in rapidly alternating and oscillatory currents, we will have some adequate conception of the part a real lightning protector must play. We do now know that if an electric current flows steadily in one direction in a cylindrical wire, this intensity is the same in all parts of the wire. [See Hertz in *Wiedemann's Ann.*, July, 1889, page 395]. But when the current alters its direction quickly, this condition no longer holds, and the interior of the wire, because of the self-inductive effects, is now in a condition, as Dr. Lodge shows,* which renders it sluggish in responding to alterations in the direction of the current. If the direction is very rapidly altered, the interior of the wire seems to become almost free from any current, the surface alone seeming to carry it. If the oscillations of the lightning currents are very rapid, then possibly the very best rod (below the points) is one of a form, such that this energy can have room, to race up and down. But this does not apply, of course, to the first part of the rod's function—that of facilitating quiet discharges. We do not believe that lightning rods were primarily designed to carry heavy and high tension currents. Undoubtedly Franklin's chief notion was that as the thunder-cloud induced a charge of opposite nature in the earth surface the pointed rod, well grounded, afforded means for a constant partial neutralization. A. M.

THE OHIO RIVER IN EARLY TIMES.—It is a common opinion that the country is now far more subject to floods and droughts than it was before the native forests were swept away. Possibly this opinion is correct; but the books written by travellers and settlers in the Mississippi valley at the close of the last century or the beginning of this one, diaries, journals, letters, etc., show that there were destructive floods and droughts then as well as now.

For example, Andrew Ellicott, the Surveyor-General of the United States, in the fall and winter of 1796-97, descended the Ohio and Mississippi rivers, from Pittsburg to Natchez, to act as commissioner of his government in running and marking the

* *Phil. Mag.*, XXVI. p. 217.

boundary line between the United States and Spain, as fixed by the treaty of 1783 with Great Britain, and re-affirmed by the treaty of 1795 with Spain, from the Mississippi river to the Atlantic ocean. Ellicott, accompanied by his assistants and military escort, made the trip in the flat-bottomed boats used at that day on the western rivers. The account that he gives in his journal of this voyage, published in 1803, contains some interesting facts bearing on the flood-and-drought question.

Ellicott and his company embarked on one "Kentucky boat" and two "keel-boats," men and baggage, at Pittsburgh, October 16, but did not get away from the neighborhood until the 24th. One cause of this detention was low water; and in the course of his narration he speaks a dozen or twenty times of the delays, dangers and damages sustained from this cause. Much time was spent in dragging the boats over bars and shoals, and repairing injuries thus sustained. On November 11, the day he left Marietta, Ellicott wrote: "The ordinary streams of water in this part of the western country so universally fail in the summer and beginning of autumn, that the inhabitants are under the necessity of having recourse to floating mills, or to others driven by the wind, or worked by horses, to grind their corn. Those floating mills are erected upon two or more large canoes or boats, and anchored out in a strong current. The float-boards of the water-wheels dip their whole breadth into the stream, by which they are propelled forward and give motion to the whole machinery. When the waters rise and set the other mills to work, the floating ones are towed into a safe harbor, where they remain till the next season. Although floating-mills are far inferior to permanent ones driven by water, they are, nevertheless, more to be depended upon than wind mills, and may be considered as preferable to those worked by horses."

He reached Cincinnati November 25, and wrote in his journal: "The waters were so low that no boats but ours had reached that place since the preceding August, and the season was so far advanced that no others could be resonably expected. Our success was owing to the number of people we had with us, and whose great submission to unusual hardships does them great credit." Ellicott reached the mouth of the Ohio December 18, but did not begin the ascent of the Mississippi until January 31. Here he was not impeded by shallow waters.

Ephraim Cutler, long a prominent citizen of Southeastern Ohio, descended the Ohio from Williamsport to Marietta in

August and September, 1795. In his autobiography, Mr. Cutler speaks often of the difficulties that he encountered in floating his "small Kentucky flat-boat" down the stream. He was often aground on sand-bars, and suffered embarrassing detentions (See "Life of Ephraim Cutler," Chap. II). On the whole, the Ohio in old times, as in our times, did not altogether undeserve John Randolph's contemptuous description, "a stream that was frozen up all winter and dried up all summer."

B. A. H.

CLIMATOLOGICAL NOTES.—The grip was very prevalent in the region of the Great Lakes during March. At one time it was reported that one-third of the guests in the Chicago hotels were ill with it, and the death-rate of the city was about doubled. It was even worse in some of the other cities.

—In these days of interest in the cure of consumption, it may be well to call attention to the climate of New Mexico, which has a very favorable action on many maladies of the lungs. Altitudes of suitable places of residence vary from 4,000 to 7,000 feet. The air is pure and dry, and the temperature usually warm. General storms are rare; rain usually comes on local storms. The Texas "Northers" are only felt in the eastern part of the territory.

—Dr. Müllenhoff, in the January number of the *Zeitschrift fur Luftschiff fahrt*, studies the recorded effects of rarefaction of air on the human body and finds, from Bert's experiments in an air-chamber, from balloon-ascents and from mountain climbing, that these effects are slight. He finds only: 1. Increase in feeling of weight in the extremities, due to the release of the ball and socket joints from pressure; 2. Certain changes in the blood and disturbances of the circulation; and, 3. Distress in the ear when the Eustachian tube is closed. The chief discomforts in high balloon-ascents are due to the cold, to the hurry and anxiety, and to the breathing of escaping gas. In the case of mountain climbing they are due to anxiety, to the severe bodily exercise, and to the unusual light and heat of the sun. When M. Janssen was carried up Mount Blanc last year he felt nothing of mountain sickness.

—The Boulder Hot Springs are in the Rocky mountains, about half way between Helena and Butte. They have long been known as curative in rheumatism and ailments of the digestive organs. New and commodious buildings have recently been

erected and the place rendered easily accessible. There are four hot springs with temperatures ranging from 128° to 140° F. The waters contain sulphur, iron, and bromides. The place is picturesque, pine forests are near, and hunting and fishing are good. The elevation is 5,600 feet.

—The beautiful Lake Chelan, in the center of Washington and just west of the Columbia river where it runs south, has been buried in an Indian reservation, but is now open, apparently, for settlement. It is sixty-eight miles long, and quite narrow, extends into the heart of the Cascade mountains, is fed by springs and small mountain streams, is filled with cold and clear water, and is a favorite home of trout and other fish loving cold water. The climate is dry and sunny, cool in summer and warm in winter, and the surroundings of the lake are very picturesque. Large game is abundant.

—Montana is about as favorable for consumptives as is New Mexico. Dr. J. J. MacDonald writes at some length on the subject in the *Northwest Magazine* for April. A strong chinook wind was reported at Livingston on March 9.

—That the people approve of a moist climate is shown in the following abstract from a census bulletin issued on March 26, published in the daily papers: Nearly all the population of the United States breathes an atmosphere containing 65 to 75 per cent. of its full capacity of moisture—that is, the atmosphere is from two-thirds to three-fourths saturated. In 1890, 57,036,000 out of 62,622,250 were found in this region, in 1880 46,559,000 out of 50,155,783, and in 1870 36,273,000 out of 38,558,371. The number of inhabitants living in a drier atmosphere was at each census comparatively trifling, numbering in 1870 less than half a million, and in 1890 less than two millions. In the moister atmosphere were found larger numbers scattered along the gulf coast and the shores of Washington and Oregon. The most rapid increase has been found at the top and bottom of the scale, and particularly in the more arid region, where the population has nearly doubled during each of the last two periods.

—The mortality of workmen on the old Panama railroad is well known, and the popular estimate of it has crystallized into the statement that each tie on this road represents a dead man. Now, after the work on the canal, the expression is modified, and runs "the space between Panama and Aspinwall is one continuous graveyard." From 8,000 to fifteen thousand people are buried at Monkey Hill, near Aspinwall alone, and this is but the

beginning. No one seems willing to estimate the grand total.

—"Death Valley," Inyo county, California, in the southeastern county of the state, has had a fearful reputation, but this has been exploded by a party sent by the Department of Agriculture to explore it. Their surveys occupied six months, yet they have lived to tell the tale. Engineer McGillvray gives the following report of its meteorology to the New York *Sun:*

"In the months of December, January, and February, our party suffered more from cold than heat, while terrible alkaline dust and sand storms swept up the valley from the south, wholly stopping our work at times. I never saw a drop of rain fall there. The sky was always cloudless. Strange to say, while it neither rains nor snows there, and but rarely in the adjoining desert country, there are seven springs of water that differ from each other in temperature and alkaline saturation rising to the surface in an oasis in what is called Furnace Wash, one mile east of the valley. The volume and character of the flow of water from these springs never varies. From the dip of the strata one might suppose they originated in the great Owens Lake, sixty-five miles to the west, beyond the lofty Telescope Mountains.

"On March 3, the thermometer registered 103° Fahrenheit, in the shade, in Death Valley. In July, a thermometer incased in wood and hung up in the shade, registered 130°. To one who has seen 100° in the shade in New York City it would seem impossible to live where the atmosphere was at 130°. But in New York on the hot days there is often as high as 98 per cent. humidity, while in Death Valley there is very little humidity in the air—during some of the hottest afternoons less than 1 per cent. Though we were constantly drinking we never felt the moisture of perspiration, but we suffered much from direct heat. The temperature of Death Valley is probably higher, and the humidity less than at any place in the world where a record has been kept. The highest recorded in the Sahara was 127° Fahrenheit, while from the border of the Persian Gulf comes a record of 128°.

"I know of no case of sunstroke in this climate, although several men exposed to the high temparature suffered a somewhat similar affliction. After a short exposure to the sun during the afternoon, without water to quench the thirst, they suddenly became demented. With proper care they were usually restored after a few weeks."

Items of Interest.—The telephone has again appeared as a means of forecast of storms. We clip the following from an exchange:

"By placing two iron bars at seven or eight meters distance from each other, and then putting them in communication on one side by a copper wire covered with rubber, and on the other side with a telephone, a storm can be predicted at least twelve hours ahead through a dead sound heard in the receiver. According as the storm advances the sound resembles the beating of hailstones against the windows. Every flash of lightning, and, of course, every clap of thunder that accompanies the storm, produces a shock similar to that of a stroke of a stone cast between the diaphragm and the instrument."

—The latest Dakota plan for a water supply consists in the sinking of artesian wells, the construction of storage basins for temporary surplus, and the construction of irrigating ditches. A great difficulty is found in their hot winds and chinooks, both of which have great evaporating power. The storage basins would probably have to be completely inclosed. It is but right that the general government should aid, at least to the extent of offering a bonus on successful wells.

—Justice Field has collected some facts concerning the terrible power of water when in swift motion, and we take some of his facts from the New York *Chronicle*.

"Mr. Louis Glass, for sixteen years the superintendent of the Spring Valley mine, assures Justice Field that he has seen an eight-inch stream, under 311 feet of vertical pressure, move in a sluggish way a two-ton boulder at a distance of twenty feet from the nozzle; and that the same stream striking a rock of 500 pounds would throw it as a man would throw a twenty-pound weight. 'No man that ever lived,' adds Mr. Louis Glass, 'could strike a bar through one of these streams within twenty feet of discharge, and a human being struck by such a stream would be killed—pounded into a shapeless mass.'

"Mr. Augustus J. Bowie, of San Francisco, the author of a standard book on hydraulic mining, estimates that the stream from a six-inch nozzle, under 450 feet vertical pressure, delivers a blow of 588,735 foot pounds every second, equivalent to 1,070 horse power. 'It is absolutely impossible,' says Mr. Bowie, 'to cut such a stream with an axe, or to make an impression on it with any other implement.'

"After an elaborate series of computations, Professor Samuel

B. Christie, of the University of California, an eminent authority on mining and metallurgy, reports to Justice Field that if a nozzle of from six to nine inches diameter were specially arranged to throw a stream vertically upward against a spherical boulder of quartz weighing 1,000 pounds, the vertical head being anywhere from 100 to 500 feet, the boulder would be forced up until the diminished velocity of the stream established an equilibrium of pressures. There would be a point at which the upward pressure of the stream would exactly balance the gravity pressure of the boulder, holding it, the half-ton rock, there suspended. In practice, of course, the boulder could not be balanced accurately upon the axis of the stream, but would fall to one side or the other. As to cutting these streams, Professor Christie says that he has often tried to drive a crowbar into one of them. The stream felt as solid as a bar of iron and, although he could feel the point of the crowbar enter the water for perhaps half an inch, the bar was thrown forward with such force that it was almost impossible to retain it in the grasp. An axe swung by the most powerful man alive could not penetrate the stream; yet it might be cut by the finger of a child, if the child were seated on a railway train moving parallel with the stream in the same direction and with the same velocity. That velocity would be considerably more than a mile a minute."

—President Harrison has recently, by public proclamation, added a large territory to the Yellowstone reservation. The proclamation adds to the east side of the park a strip about twenty miles wide, and a wider strip on the south extending over the great Rocky Mountain divide as far west as the line of the State of Idaho. There are large forest tracts in the teritory added to the park on the south, and if the powers of Captain Anderson, who has command of the military police in the park, are extended over the added section, the forest will be protected from the woodchopper as well as the hunter, and if the water supply is maintained by protecting the forests, the great rivers rising in the reserved section will be kept in almost their present condition, and remain conservers of the water started in the mountains.

—It is claimed that the finest forest preserve in the United States is the Adirondack region, and that the Black Forest in Germany, the Norway forests, and the forests of Canada cannot be compared with it. There are 2,760,000 acres in the region, which it is proposed to include in the Adirondack Park.

—The Sequoia park in Tulane county, California, has been set aside as a national reservation and is now to be protected, by a troop of cavalry, from depredations. This includes five townships, or about 180 square miles, and embraces the ground covered by the finest of the big trees. This is some distance from, and many times larger than the Yosemite National park.

—The following is a news dispatch printed March 12. We will not venture to comment at present: "Professor Carl Myers, of Frankfort, N. Y., has returned from Washington, D. C., where he was called to consult with officials regarding the carrying out of an extensive scheme for promoting rainfall in arid regions or during seasons of prolonged drought by producing concussions in upper atmospheres, for which Congress has made appropriations. Professor Myers will begin operations with one hundred balloons of various sizes. The charges of mixed gases will be exploded at various heights through the medium of galvanic batteries and electric cables which will serve both to retain captive balloons and conduct the electric spark to explosive compounds. The necessary work will be done on his balloon farm at Frankfort, where the oxygen and hydrogen will be generated. Experiments will be made at Frankfort and near Washington; finally the sky-stormers will be taken to the arid regions of Texas, Colorado, and other states.

THE CAUSE OF INFLUENZA.—At the annual meeting of the Michigan State Board of Health, the secretary, Dr. Baker, reported, "*That he had worked out the cause of influenza.* He said its greatly increased prevalence during the last three months is alarming, because so many other diseases follow that disease, and increase after it increases; the diseases which so increase being consumption, pneumonia, cerebro-spinal meningitis, rheumatism, osteo-myelitis, etc.,—influenza seeming to bring in its train all of these most important diseases. Doctor Baker explained the causation of influenza. He stated that the germs of influenza are generally, at all times, present, but that there must be certain coincident meteorological conditions to irritate the throat and air passages sufficiently to let the germ gain an entrance to the body. These meteorological conditions, in this instance, were the excessive prevalence of north and north-east winds, and the excessive amount of ozone during the past three months.

The prevention of influenza, and of the coincident rise in the other more dangerous diseases, has not been possible, because of ignorance of the causes. Now the causes are known, and the study of the measures for the prevention can begin."

Influenza then, it would seem from this statement, is the product of four factors—a germ, north and north east winds, ozone and an irritation of the throat, or air passages. Given a coincidence of such conditions, and the sneeze must follow. But, even should a champion step forward, ready and willing to grapple with such conditions, are we prepared to assure him that our factors are causes rather than coincidences? Are we even prepared to assert that a germ has yet been discovered which, under suitable conditions, excites the symptoms characteristic of influenza. We do not yet know how extensively Dr. Baker's investigations have been carried into the various outbreaks of epidemics of this character, or whether he has found the north and northeast winds and the excess of ozone invariable conditions in all of them. But, granted that he has satisfied himself, and is prepared to satisfy others on this point, the presence of a causative germ must be more than an assumption before the work of prevention can make much headway, since this is the only one of the factors against which preventive measures can be marshalled with much hope of success. W. J. H.

CORRESPONDENCE.

"THE TORNADO."

TO THE EDITORS: There have been three notes upon, or notices of, this book in this Journal recently: In November, p. 337; December, p. 404, and March, p. 568. The first of these, by Prof. Ferrel, I have already commented on in "Science" for October 17, p. 48. I desire to briefly remark upon the others. I am very much pleased that this subject has been agitated and I hope that the agitation will continue. Prof. Marvin has tried Espy's work on a slightly different plan and says he gets substantially the same results. It would be interesting if we had more of the details of the experiments. It is probable that the velocity of expansion used was like that of Espy's explosives, thousands of feet per second. My own experiments were tried at much lower velocities so that there is no essential contradiction in these results. I must differ with Prof. Marvin's views

in regard to the saturation of air when it is compressed. I had repeatedly noted the deposit of dew on the sides of the jar in which the nearly saturated air had been compressed, this was owing to the fact that the dew point of the air had been raised by the compression and in consequence moisture was deposited on the inside of the jar which had remained at the air temperature. It certainly does not show that the air was saturated. It is a little singular that Mr. Velschow has fallen into a serious error in the same line. On seeing moisture collect on the side of the jar he thought it was squeezed out, so to speak, by the compression and upon this view he founded an elaborate theory of the formation of rain by the descent of masses of air which squeezed out the moisture by compression.

My reviewer in the March JOURNAL thinks that I have not given enough credit to the labors of others. I make direct quotations covering the work of Finley, Espy and Ferrel in more than twenty pages and devoted more than twenty pages to a discussion of these views. The book was to be a popular exposition and did not permit the more abstruse calculations. There seems to be an impression that I have denied the values of accepted constants in physics—this I have never done. I have denied most emphatically that granting these values we have one scintilla of evidence that they can help us to a determination of the forces and combinations which form our storms and especially tornadoes. It is also objected that I have left the beaten tracks and have appealed from the known to the unknown. I do not think this presents my view exactly. I have simply asked for more light and have very carefully avoided any theories, though I have suggested what seemed promising lines of study. As to what is really known to-day, perhaps a quotation from a recent publication will be the most satisfactory method of presenting my views. Mr. Eliot, in "Hand-book of cyclonic storms in the Bay of Bengal," shows the enormous energy which is stored up in the clouds through the evaporation of water from the Bay amounting to a steam power which would be represented by the evaporation each twenty-four hours of 75,000,000 tons of water on a single square degree. He also shows that in some rains the process of condensation is forty times as rapid as that of evaporation. He then says, page 58:

"The energy given up during condensation appears to be communicated to the air directly and produces rapid increase of

its motion. The aqueous vapor in this case may hence be compared to the coal which is necessary to heat the boiler of a steam engine or steam vessel. Each of them, *i. e.* coal and aqueous vapor, contain a certain amount of energy per pound of mass. In the one case the coal gives up its energy by the process of burning or combustion to the water or steam in the boiler, in virtue of which it is able to move the mechanism of the vessel. In the second case the aqueous vapor gives up a portion of its energy whilst being converted into water by the process of condensation, and communicates that energy to the air which is hence put into violent motion." If this is not a good example of passing from the known to the unknown I do not understand the force of language. If we had a thousand tons of gunpowder in a single mass it would represent an enormous potential energy which could be easily calculated in foot pounds, if now this mass could be distributed over a square mile it would make a depth of two millimeters, surely no one would expect very great liberation of energy if gunpowder were fired under this condition. The amount of available energy in the atmosphere from the condensation of moisture must be vastly less than would accrue from the gunpowder under these conditions.

It seems to me the recent discussions on many of the fundamental principles of meteorology have a significance which cannot be exaggerated. Certainly I do not wish any better corroboration or support of my position in regard to the energy to be derived from the condensation of moisture in the free air than has been afforded by the published opinions of so eminent an authority as Dr. Hann, of Vienna.

H. A. HAZEN.

April 6, 1891.

CONCURRENT AND CONTRASTED WEATHER.

TO THE EDITORS.—In the Journal for March on page 552, Professor Hann in a foot-note calls attention to the storm of July 12, 1890, which was attended by snow in the Alps and extraordinary cold. It may be worth noting that coincidently with this storm there was a precisely similar condition of affairs in the eastern United States, there having been snow on Mt. Washington and severe cold in many localities along the Atlantic coast from Georgia northward to New England. It is one of a long series of instances in which phenomenal weather conditions have co-existed on both sides of the Atlantic, consti-

tuting typical cases whose careful study may perhaps yield a better insight into the laws governing atmospheric movements. The fact of the existence of periods in which storms acquire great intensity in localities far removed from each other is too important and suggestive to be disregarded, or simply dismissed with the remark that such things are liable to happen at certain seasons of the year. The fact is that these phenomenal outbursts of storm energy have been noted during every season and during almost every month in the year. Note, for example, the intensification of storms on both sides of the Atlantic on Octocer 14, 1886, May 12, 1886, March 12, 1888, December 5 to 8, 1886, etc. Another feature of the same subject that demands attention is the rearrangement of the distribution of pressure in precisely the same way over both continents in certain years. Compare, for example, the distribution of pressure and location of storm tracks in Europe and America with each other during the winter of 1889-90, and likewise during the winter of 1890-91. In the former year anti-cyclones remained persistently in lower latitudes and storm tracks were deflected far north, probably even within the Arctic circle, ice coming down all winter on the Atlantic. In the steamer lanes there were incessant westerly gales and there were also very high average temperatures over northern Europe and the northern part of this continent. So pronounced were these characteristics that they became the subject of general comment. In the year following, however, there was a decided change. Storm tracks, instead of passing north of the lakes, appear in the southern part of the United States, and anti-cyclones are located northward instead of southward from their centers. Arctic ice no longer comes down as in the preceding year, but is comparatively scanty and confined to the latter portion of the winter only, as is most usually the case. The steamer lanes are the seat of anti-cyclones, whose centers are so far north that there is a predominance of gentle easterly winds. Indeed, for extended periods, the trade winds appear to have invaded the region of anti-trades throughout the winter. In Europe, likewise, the same peculiarities are manifest. Storm tracks are located far south, entering Algeria at times, and anti-cyclones are located northward. In February, for instance, Great Britain was almost absolutely without rainfall because of the unusual persistence of an anti-cyclone in that location. In short, the contrast between these two winters is unmistakable, and the coincidence of the contrasted peculiari-

ties throughout a very large section of the northern hemisphere is equally plain. I have made a list of instances in which the seasons on both sides of the Atlantic have been marked by strongly defined peculiarities of the sort indicated. During the winter of 1856 there was extraordinary cold with reference to which Blodgett says in his "Climatology of the United States," on page 153, "While the middle and lower latitudes of both continents participated in the refrigeration, the higher latitudes of both the north of Canada and Labrador here, and the north Baltic countries of Europe, Archangel and the high Atlantic coasts of Norway and the British Islands were alike warmer than usual, particularly in December and January." 1780 and 1740 were years in which a similar condition existed to even a more marked extent, the intensity and persistence of the cold both in America and Europe being far greater, perhaps, than in any other instances on record. In like manner the cold summers in America and Europe in 1812 and 1816 are without parallel. In all these cases, and many more that might be mentioned, there was an abnormal distribution of atmospheric pressure continuing for months and even years in certain instances, so that single seasons, or a succession of seasons were marked by very decided peculiarities over every part of the earth from which information is to be had. To my mind this is the crucial point in meteorology. So long as there is no adequate explanation of these variations on so grand a scale from year to year, there can be no security that there is any positive knowledge whatever in regard to the real nature of the forces concerned in the rearrangement of the distribution of atmospheric pressure. In like manner also, and consistently with any explanation that may be adopted in regard to seasonal variations, an insight should be had into the sudden intensification of individual storms which is so common, and which occurs not unfrequently in localities remote from each other at almost precisely the same times. If solar heat be the chief or only agent that puts the atmosphere in motion, it is necessary to enter into detail as to the manner in which it produces such variable effects from day to day and from year to year, without undergoing itself any change that can be detected by the most refined methods hitherto devised.* If any systematic attempt has been made thus to

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*In a recent letter to the writer Professor Christie states that the investigations n regard to variability of solar heat by the Solar Physics Committee are thus far neconclusive.

enter into detail, the writer has not received information in regard to it. The quickening of the trade winds, and precipitation within the tropics have been mentioned as serving to account for the variability in the higher latitudes. Obviously, however, they are manifestations of the variability in question, rather than in any proper sense, its cause. Personally, I have very little to offer as yet, although for several years I have been engaged in an investigation in reference to the possibility of a magnetic control of the winds, and have obtained certain results that look very promising as far as they go. My present purpose will have been served if I shall have indicated what seems to me to be the chief questions at issue. Perhaps, if you see fit to publish this, some poor, down-trodden sun-spottist may be encouraged to continue his theorizings, or perhaps not. In any event, those who are desirous of maintaining a reputation for orthodoxy have very little to boast of in the way of achievements in connection with problems here referred to. Orthodoxy at present consists rather in a willingness to admit that one does not know and is willing to learn.

Lyons, N. Y., April 6, 1891. M. A. VEEDER.

BOOK NOTICES.

INVESTIGATIONS OF THE NEW ENGLAND METEOROLOGICAL SOCIETY, for 1889, form Part II, of Volume XXI, of the *Annals of the Astr. Obs. of Harvard College*, (pages 107–273, 14 plates). The publication consists of observations of the N. E. Met. Soc. for 1889, (47 pages), in which are discussed several features of interest and appended to which are monthly and annual tables of the elements at the stations of the society. An investigation of the sea-breeze by Professor Davis and Messrs. Schultz and Ward occupies 48 pages. The sea-breeze investigated was that of the coast from Portsmouth, N. H., to Plymouth, Mass., and reports were received from 130 observers. The final paper (9 pages) is by Professor Upton, and is on the characteristics of New England climate. The whole forms a very valuable addition to the knowledge of New England climate and of sea-breezes.

THE COAST AND GEODETIC SURVEY report for 1888 contains, in appendix 6, some historical notes on terrestial magnetism, so far as it comes within the field of the service. Appendix 7 (pages 177–312) contains a new (the seventh) publication of the

secular variations of the magnetic declination in the United States and at some foreign stations. The publication immediately preceding this was in the report for 1886. It included 94 stations, this report brings the number up to 109. Appendix 8 gives the geographical positions of trigonometrical points in Connecticut, 325 in number. In appendices 10, 11 and 12, are given the results of spirit-leveling of precision in Alabama, Mississippi, Louisiana and Arkansas.

COLD WAVES.*—In this report Professor Thomas Russell gives the statistics of cold waves from January, 1880. The conclusions drawn have reference to the practical point of the prediction of the phenomena. The report forms a very valuable contribution to the literature of the subject.

In November, 1889, a change was made in the official definition of a cold wave. According to the new rule the fall of temperature must be at least 20° F., and the temperature must drop to the freezing point or below. A verification is admitted when, for New England and regions north of a line struck from New York City to the north point of Texas (approximately), the fall is 18° and the temperature reaches 18°, south of that, except for a strip 100 miles wide along the Gulf Coast, a fall of 16° and a temperature of 36° F. are required. In Florida and along the Gulf Coast frost-warnings only are sent out.

A JOURNAL ON AGRICULTURAL PHYSICS which is not as well known in this country as it ought to be is Dr. Wollny's *Forschungen auf dem Gebiete der Agrikultur-Physik*, which is published at Munich and appears in quarterly parts,—five parts to the volume. The thirteenth volume is completed with the first part for 1891. It makes an octavo volume of 476 pages, with five plates. Its contents are made up of original articles and bibliographical notices and notes. They are classified under three heads: I, Physics of the Soil; II, Physics of the Plant, and III, Agricultural Meteorology. Under the last head are included the relations of climate and meteorology to cultivated plants and the dependence of climate and meteorology on the nature and clothing of the surface. Under this head there have appeared in the last volume an article by Dr. Wollny on the

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*Signal Office, War Department. Extract No. 5, from the Annual Report of the Chief Signal Officer, 1890. Report upon Cold Waves, Washington, 1891, 8°, pp. 69-184, 99 charts.

penetration of rain into the soil (41 pages), another by the same author on the influence of the forest-litter on soil temperatures and humidities (51 pages), and an article by Dr. Ebermayer on the hygienic significance of forest-air and forest-soil (51 pages). These articles are of the highest character, the bibliographical notes are judicious and useful, and the list of co-editors includes the most eminent names in these branches of science. Among them we note two well known American professors, Dr. Hilgard and Dr. S. W. Johnson.

BIBLIOGRAPHY OF WINDS.*—This is the third portion of the Signal Service Bibliography, the two previous ones being on Temperature and Moisture. It is on the same plan as the preceding, but contains references to about 2,000 books and papers, while the preceding referred to 4,400 and 5,500 respectively. The three together we estimate as about one-tenth of the entire bibliography of meteorology, as planned by the service. A fourth part, on Storms, is in preparation, and General Greely expresses the hope that it will be issued by his service as Part IV.

This part is classified under the headings : General Atmospheric Circulation, Winds in General, Wind Velocity in General, Variation of Wind Velocity, Wind Velocity and Barometer, Wind Pressure, Wind Direction in General, Variation of Wind Direction, Prevailing Wind Direction, Geographical Distribution, Trade Winds, Monsoons, and Special Winds. The latter includes the bora, the foehn and chinooks, land and sea breezes, mistral, mountain and valley winds, including the helm wind, northers and blizzards,sirocco, harmattan, khamsin and simoon. Instruments for the measurement of winds are not included. They are to be treated under a separate division of instruments.

These are a real god-send to students of meteorology and climatology. The literature of meteorology has assumed an enormous volume, and a key to it, even though not ideally perfect, is of the greatest value. The lacks of ideal perfection, which we have in mind, in this bibliography, are the incompleteness of the lists after 1881, and the awkward form in which it is printed. We are very glad that the publication is made, even

* Bibliography of Meteorology. A classified catalogue of the printed literature of meteorology from the origin of printing to the close of 1881, with a supplement to the close of 1889, and an author index. Prepared under the direction of Brigadier General A. W. Greely, Chief Signal Officer U. S. Army. Edited by Oliver L. Fassig, Bibliographer and Librarian, Signal Office. Part III—Winds; Washington City, 1891; 214 Type-written pages.

with these drawbacks, and we think that the Signal Service deserves the gratitude of meteorologists for the work. It is to be hoped that the new weather service will give us the other nine-tenths of this important work.

A CONVENIENT COLLECION OF MATHEMATICAL FORMULAS.*—Such a collection is that of Dr. Láska, which is being published in parts. The first part was published in 1888, and contains 295 octavo pages devoted to algebraic analysis, including the Calculus. In addition to the leading formulas in this great field, it contains tables of integrals (168 pages), and sixteen numerical tables, including numerical integrals. The second part, published in 1889, and of nearly the size of the preceding (280 pages), gives the formulas for the theory of functions, and for geometry. The third part is divided into two, of which the first, printed in 1889, gives the formula for the physical sciences. It contains 200 pages, and includes mechanics, physics, and probabilities. The second half has not yet appeared. It is to be devoted especially to astronomy, and to a complete index of the entire work.

THE KANSAS AGRICULTURAL REPORT.†—This is an excellent report, the varied contents of which are indicated in the foot note. It is well calculated to give the farmers authentic information concerning their own state, and is creditable to the Board of Agriculture, which made it, and to the legislature, which printed it so promptly. Among the contents are statistical statements as to tree planting, an account of Kansas salt and gypsum, of the loco weeds, of irrigation in Kansas, of the sugar industry, and the *resumé* of their meteorological service, the last occupying nineteen pages. All these papers are made with care and evidently the work of competent persons.

The paper of most interest to meteorologists is that of Prof. G. E. Curtis on the "Hot Winds of the Plains." It occupies

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*Sammlung von Formeln der reinen und angewandten Mathematik von Dr. W. Láska, Braunschweig, Friedrich Vieweg und Sohn, 1888--.

†Seventh biennial report of the Kansas State Board of Agriculture to the legislature of the state for the years 1889-1890, containing descriptive statements. statistics and general information relating to each county, and the geographical and topographical features of the state, together with tables, statements, summaries and diagrams, showing the products, progress and development of the state; reports of appointed officers of the board, etc., etc. Topeka. Printed by the state, 1891, Octavo, 260 pages, map of the state and many diagrams.

twenty-two pages and has been reprinted as a pamphlet. It is the result of a detailed study of the subject, depending, in part, on special observations. According to Prof. Curtis the hot winds are southwest winds, not necessarily strong, occurring in the hottest hours of the day in the hot months over Kansas, Nebraska and Dakota. Their especial characteristics are: unusually high temperatures and unusually low humidity. During their occurrence there is always an area of low pressure to the northward. They are only the "warm wave" or "heated term" of the region farther east in which the bare, level, arid soil gives rise to an aggravation of heat and expansion. They first dry out the soil and then, if they continue, wilt, and even wither tender plants. They accompany drouths and render their effects still more irremediable. A remedy is to be found in moisture economy and this would perhaps be aided by planting trees.

FORM OF THE CELESTIAL VAULT.—Dr. Eugen Reimann has published elaborate studies on this subject. *His process consisted of bisecting, with the eye, a vertical arc of the sky and then measuring the corresponding vertical angle. With this data a simple mathematical process enables him to deduce the horizontal and vertical diameters on the hypothesis that the sky is a part of a spherical surface. The subject has been considered by a few others and is of interest to meteorologists because of its relation to cloud estimates.

The resulting values are given in terms of the vertical angle for the estimated middle of the vertical quadrant. This he found for daylight observations, in his first paper, to be 21°.47 instead of 45° as it would be if the celestial vault appeared a hemisphere. This makes the horizontal diameter of the sky 3.66 times the vertical height, and gives for the radius of the sphere to which the visible sky belongs a value 7.19 times the vertical height. The angle above mentioned varies a little with the state of the weather. The latest value decreases the angle slightly, making it 21°.22. The curvature varies with the season, weather and time of day. The sky is flatter in winter and spring, in cloudy weather and at night.

*Beiträge zur Bestimmung der Gestalt des scheinbaren Himmelsgewölbes, Programm des K. Gymnasiums zu Hirschberg, Ostern, 1890. Sonderabdruck, large octavo, fourteen pages. Also a paper with similar title from the programm of 1891, sixteen pages.

The assumption that the celestial vault is a spherical cap seems open to objection. If it is of this character the horizon should be closed in by the sky at an acute angle, an angle in fact which is very acute. In winter this appears to be the case only when the sky is covered by low-lying clouds. At other times, day and night, the sky appears to come down to the horizon at nearly a right angle. This would mean an ellipsoidal segment instead of a spherical one, and aereal perspective, with its gradual weakening of the light toward the horizon would certainly cause the vertical quadrants to appear to be elliptical.

SECULAR CHANGES OF CLIMATE.*—The oscillations of the Alpine glaciers have long attracted the attention of investigators, and Sonklar, Forel, Richter and Lang, have succeeded in showing that they followed certain variations of the climate in the region of the Alps. Dr. Brückner shows that there is a synchronous periodic change in the case of the Caspian, and, less clearly, in the case of forty-four lakes without outlet scattered over the entire earth, including Australia. This shows that there is a synchronous periodic change of climate over the entire earth, and this book is, for the most part, devoted to the determination of the period and characteristics of this variation, in the course of which 36,900 years of observation are used.

The period in question proves to have a duration of thirty-five years. The last minimum of temperature was in 1876 to 1880 and we are now approaching a maximum. The amplitude of variation of temperature on an average for the whole earth is 1°.37 F. which corresponds to a swing of the isotherms through about three degrees of latitude. With the variation of temperature comes a change in the variations of the barometer. The latter are always greater during the warm part of the period, less during the cold. Over the continents the cool periods are relatively wet, the warm dry; exceptions to this rule, twenty per cent. of all the cases, group themselves about the oceans. The synchronous variations in rainfall increase in intensity with increase of continental character in the stations. For continental stations the change of rainfall from warm to cold periods is twenty-four per cent. of the mean rainfall; including conti-

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* "Klimaschwankungen seit 1700, nebst Bemerkungen über die Klimaschwankungen der Diluvialzeit." Dr. Eduard Brückner, Professor of Geography at Berne. Penck's Geographische Abhandlungen, Volume four, part two. Vienna, 1890. Large octavo, 324 pages and one plate.

nental and maritime stations, it is only twelve per cent. For the last two centuries the middle of the wet periods has fallen on the years 1700, 1740, 1780, 1815, 1850 and 1880, of the dry on 1720, 1760, 1795, 1830 and 1860.

The cause of this periodic variation is still unknown. It raises and lowers the level of seas and rivers, enlarges or contracts glaciers, accelerates or retards the maturing of plants, and grasps deeply into human life in that it influences commerce, agriculture and health. It is probably only one of several periodic oscillations of climate. The eleven-year period, coincident with that of sun-spots, the author considers non-existent, or at least insignificant. The others of shorter period he does not take into account. Of longer periods than that of thirty-five years he thinks he finds distinct traces of two. One is of geological duration and has been the controlling feature in the present historical period and caused the glacial and interglacial times. The other is a period of only a few hundreds of years and of this there is historical and geological evidence. The actual changes of climate which we have undergone are due to these three interfering periods, of differing durations and amplitudes. In accordance with the known results of composition of several harmonic motions, the resultant will be complicated and apparently irregular. Only a complete knowledge of epochs, phases and amplitudes, will enable us trace or predict the resultant with anything approaching certainty.

This appears to us the best contribution yet made to the subject of variations of climate. The amount of labor expended on it must have been great, and care and conscientiousness are displayed on every page. It is a source of regret to us that the author could with reason speak of American data as he does on page 151. At the same time it seems true that in hydrographic questions he did not avail himself of the best American material,—that afforded by the Coast and Geodetic survey, and that of the engineers of the army.

METHOD OF LEAST SQUARES.*—The method of least squares affords processes for determining the probable error of observation, the solution of observational equations, the determination of empirical curves and similar problems which could properly receive more attention from meteorologists than they have here-

* "An Elementary Treatise on the Method of Least Squares with Numerical Examples of Its Application." Professor George C. Comstock. Octavo. 74 pages. Boston. 1890.

tofore done. We frequently receive requests to recommend a book on the subject which can be used by those whose lack of mathematical training does not permit a clear comprehension of the theory of the subject. To such Professor Comstock's small book may be commended, though not without reservation, because, while elementary, it still requires some knowledge of the Calculus. Still it can probably be used by those to whom this branch of mathematics is unfamiliar, as the subject is treated entirely from the empirical stand-point.

MR. LANCASTER'S ANNUAL VOLUME.*—On the climate of Belgium, appears promptly and in its usual form. In addition to the usual meteorological resumés, there are many notes on local storms and on the appearance of plants and movements of migratory birds. The effects of electric storms and the occurrence of late frosts are also noted. A case of ball-lightning is recorded from Theux on the tenth of August. It was heart-shaped and descended to thirty or forty feet of the surface when it exploded with a formidable peal of thunder, disappearing in a series of zig-zag sparks directed horizontally and downwards. A tornado occurred on the same day in the southeastern part of the kingdom. It came in a heavy wind and rain and passed through a fine forest where it did much damage. This must be a very interesting collection of data to intelligent Belgians, and we do not see why many of the states should not support similar publications in this country.

THE CATALOGUE OF THE LIBRARY OF THE ROYAL METEOROLOGICAL SOCIETY, for 1891, contains 222 octavo pages and about 4800 entries. It is arranged under the name of authors and is indexed under subjects. Only separate publications are indexed. Journal articles, unless printed as separates do not appear. Mr. J. S. Harding, Jr., is the cataloguer.

METEOROLOGY IN 1889.†—The bibliographical list by Mr. Fassig, which follows this paper, contains over three hundred

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* Le climat de Belgique in 1890, par A. Lancaster, Météorologiste–inspec teur, etc., Brussels, 1891. Duodecimo, 149 pages.

† An account of the Progress of Meteorology for the year 1889, by George E. Curtis. From the Smithsonian Report for 1889, Washington, 1891, Octavo, pages 205-285.

and fifty titles by nearly two hundred and fifty authors. The text of this paper contains a great deal of condensed information often put in a happy form, but in reading it we were occasionally struck by the absence of publications which we might properly expect to find mentioned in it. For instance, we missed the pleasant book of Dr. Rosten, entitled "L'Aria atmosferica," and Guillaume's excellent "Thermométrie de précision," and the highly important *Repertorium fur Meteorologie* for this year. But it is the neglect to do justice to American meteorological progress that we find it hardest to excuse. We do not find in these eighty pages a single reference to the state services or to their army of underpaid observers. There is no reference to Sergeant Barwick's large report on the climate of California, and it would not be difficult to make a list of a score or two of really valuable American meteorological studies to which no reference is made.

EXCESSIVE HEAT IN CALIFORNIA, IN JUNE 1859.—Apropos of a newspaper report that a shade temperature of 133° F., had been recorded, Sergeant Barwick has collected together all available information concerning the hot period in California, in June, 1859. As we are not likely to have any better record of this extreme temperature, and as it is of considerable interest in connection with the question of possible fluctuation of temperature in California, we reprint Sergeant Barwick's article from the Sacramento *Bee*, leaving out only something of what he says, relating to the psssibility of extreme temperatures in San Francisco. The position of San Francisco protects it from such extremes, and, as a matter of fact, when Interior or Southern California is hot, San Francisco is but little affected.

The San Francisco *Bulletin* of June 20, 1859, says, in an editorial comment: "Some of our interior exchanges mention the extreme temperature that was experienced in their respective localities last week. In Placer county, at Ophir, on the 16th, at 9 A. M., it was 113°; at Gold Hill, 109°; Auburn, 100°, and sometimes a trifle higher; Folsom, 98° to 106° in the shade, and 130° to 135° in the sun; Martinez, 94° to 100°; Lafayette, 106° in a cool place."

The *Bulletin* of June 22d, in an editorial comment, said: "The heat of the interior districts continues intense. At Marys-

ville on the 20th, at 3 P. M., it was 109°; Stockton and Sacremento, 99°. The temperature in San Francisco has been unusually high for a week past, yet so long as it keeps below 80° in the shade, which has hitherto been the case this season, we need not complain. It is some consolation to know that if ocean winds and fogs do trouble us occasionally, the position which exposes the city to them is also free from the excessive heats of other portions of the State. The extreme heats above mentioned naturally induce sunstroke, and already one fatal case is mentioned. A man by the name of Thatcher, was killed by sunstroke on the 19th of June near Oak Grove House, about 20 miles from Marysville. He was driving at the same time a team with a load of goods from Marysville to Rabbit Creek."

The *Bulletin* of June 24th, clipped from the Marysville *Express* the following item:

"On June 22d, about 11 A. M., as the Sacramento stage came into Marysville, one of the horses dropped down in front of the Western House, completely exhausted with heat. Everything was done to relieve him, but without effect, and in the course of an hour he died. He was only driven about twelve miles. We have never known the heat to be so oppressive as it has been for several days past, nor do we ever remember its continuing so long."

The *Bulletin* of the same date clipped the following from the Marysville *Democrat*:

"On June 22d the sun was so intensely hot at the Buttes that farm hands generally were forced to give up work. One of the few who resolved to brave it through fell to the ground with a sunstroke, and was taken into the house for dead. He, however, revived. He was engaged with a threshing machine."

The *Bulletin* of June 29, clipped the following from the Santa Barbara *Gazette* of June 23d: "Friday, June 17, will be long remembered by the inhabitants of Santa Barbara, from the burning, blasting heat experienced that day and the effect thereof. Indeed, it is said that for the space of thirty years nothing in comparison has been felt in this county, and we doubt in any other. The sun rose like a ball of fire on that day; but though quite warm, no inconvenience was caused thereby until 2 P. M., when suddenly a blast of heated air swept through our streets, followed quickly by others, and shortly afterwards the atmosphere became so intensely heated that no human being could withstand its force. All sought their dwellings and had

to shut doors and windows and remain for hours confined to their houses. The effect of such intense and unparalled heat was demonstrated by the death of calves, rabbits, birds, etc. The trees were all blasted and the fruit, such as pears and apples, literally roasted on the trees ere they fell to the ground, and the same as if they had been cast on live coals. But, strange to say, they were only burned on one side—the direction whence came the wind. All kinds of metal became so heated that for hours nothing of the kind could be touched with the naked hands. The thermometer rose nearly to fever heat in the shade near an open door. During the presence of this properly-called sirocco, the streets were filled with impenetrable clouds of fine dust or pulverized clay. We see the terrible effect all around us in blighted trees, ruined gardens, blasted fruits and almost a general destruction of the vegetable kingdom here. We regret to announce that the sirocco was not as we hoped, local; but that Los Angeles was visited the same day by similar blasts and more intense, if possible, than were experienced here, and that not only fruit trees are injured, but the vineyards are reported as nearly destroyed. The highest temperature at Los Angeles was reported at 110°."

The *Bulletin* of June 29th, in its editorial comments, said: "Our interior exchanges continue to record the extremely high temperature of last week. During that period at Placerville the thermometer usually indicated from 98° to 106° at midday and at Upper Placerville, on Wednesday last, it actually rose to 115 in the shade. At Columbia, it ranged from 105 to 111; Sonora, 102 to 113; San Andreas, from 106 to 112; Oroville, in the brick court house, it reached 110; and in Wells, Fargo & Co.'s express office as high as 114. In Shasta county, in some places in brick buildings, the mercury rose to 118. In the town of Shasta, in any of the brick buildings it ranged from 100 to 108. At Petaluma, on June 22d, it was 105 over a sprinkled floor and a cool breeze. At Mokelumne Hill, in the past week, it ranged from 100 to 112; Auburn, Sunday, Monday and Tuesday, the thermometer stood at 102 in a fire proof brick building, very little wind blowing at any time; Wednesday, 104. At Ophir, the same afternoon, 114 in the shade for three consecutive hours; Gold Hill, 113; Maine Bar, on the American River, 120; Mountain Springs, 110. The thermometer ranged about 13 higher than the above figures when taken from the brick buildings and placed in frame ones. In Mariposa, on the 22d and 23d, the thermome-

ter ranged in the middle of the day from 110 to 118. On the 23d, between the Stanlulaus and Tuolumne rivers the heat was excessive, 113 in the shade. The wind was avoided, as it was heated so that it felt as if actually burning the flesh, as if it were rushing from a hot oven. In one team of ten horses three fell in the road from heat. Two died, but the other was revived by pouring sweet oil down its throat. The animal's throat was closed so that it could not drink, when the oil was used so as to soften the throat and open it so that it could swallow water, when it revived. The two that died expired before such aid could be used with them. At Burton's public house, at Loving's Ferry, birds flew into the barroom to the pitcher to get water, so tame were they made by the thirst caused by the extreme heat. Birds were seen to fall dead off the limbs of trees in the middle of the day from heat, as if they were shot. The wind was of that burning heat never before experienced by the settlers there since their arrival in the State. At Sonoma, on the 22d, it was from 110 to 112. In other localities a much higher temperature was reached, as, for instance, at Knight's Ferry it was 116 in the shade. At Weaverville, on Tuesday, Wednesday and Thursday, in Seaman's drug store, the mercury reached from 103 to 106 and 105 respectively.

The *Bulletin* of the 29th clipped the following from the Marysville *Democrat:* "We are told that the very air on the sides of the mountains and along in the foothills is so hot that it burns the mouth and throat to draw it in. Persons should be very careful at this time about traveling too far and too long in the heat of the day."

The *Bulletin* of July 1st, 1859, said that at Knight's Ferry during the hot wave the thermomter reached 118, and previous to that for a week or more it ranged from 108 to 114 and a number of mornings at sunrise the temperature was 90.

It was much hotter in June, 1877, in San Francisco than the time of the so-called hot wave of June, 1859. On June 8th, 9th, 10th 11th and 12th, 1877, Mr. Tennent's records gave the highest temperature each day as follows: 93, 95, 91, 99 and 94 respectively.

The above shows that a temperature of 133° was not recorded at any point in the state where there were any thermometers hung out. It no doubt was a hot month. The records at San Francisco only show 78°, and Santa Barbara felt heat indoors, which might mean 118 or 120° outdoors in the shade.